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Headwaters Basin

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

MISSOURI HEADWATERS BASIN
ANCHOR LAKE DAMS
BEAVERHEAD COUNTY, MONTANA
MT-821 (SOUTH DAM)
MT-1483 (NORTH DAM)

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the owner and the State of Montana Department of Natural Resources and Conservation, Anchor Lake South Dam and Anchor Lake North Dam were inspected by Hoskins-Western-Sonderegger, Inc., on 20 September 1979, under the authority of Public Law 92-367. The Anchor Lake Dams are located in Beaverhead County, Montana, approximately 23 miles northwest of Dillon.

This report was compiled from information obtained during an on-site inspection, a review of operation records, and analysis of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most private and public agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATIONS

Anchor Lake is one of four lakes in the Birch Creek watershed, owned and operated by the Beaverhead Water Company, which are intended to be used for irrigation storage. The other dams are Tub Lake Dam, Pear Lake Dam, and Boot Lake Dam, the latter two of which are downstream from Anchor Lake. The Anchor Lake project consists of a natural lake and two embankments to raise the lake elevation for irrigation storage. The reservoir has a drainage area of approximately 0.46 square miles, a surface area of about 49 acres at normal pool, and storage at dam crest of about 510 acre-feet. The project is operated under a Department of Interior easement which was filed under the Public Lands Act of March 3, 1891.

In accordance with the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1), the 11-foot-high Anchor Lake South Dam (MT-821) and the 12-foot-high Anchor Lake North Dam (MT-1483) are classified as being of small size and as having a significant (Category 2) downstream hazard potential, due to the presence of approximately 2 inhabitable structures located about 10 miles downstream of Boot Lake on Birch Creek. Discharge from a breach of the North Dam would reach Birch Creek directly. Discharge from a breach of the South Dam would reach Birch Creek by way of Pear Lake and Boot Lake, neither of which would be able to prevent the Anchor Lake discharge from reaching Birch Creek.

Inspection criteria (Ref. 1) recommend that a small-sized project with a significant downstream hazard potential be capable of safely handling a spillway design flood (SDF) in the range of the 100-year flood to one-half of the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Since Pear Lake Dam and Boot Lake Dam are both located downstream from Anchor Lake, and Boot Lake Dam is classified as being of intermediate size and is required to handle at least one-half of the PMF, we recommend that this project be capable of handling one-half of the PMF.

During the dam safety analysis, an estimated PMF was developed for the drainage basin resulting from a 24-hour storm. The resulting PMF has a volume of approximately 370 acre-feet. The reservoir level at the beginning of the 24-hour storm was assumed to be at the principal spillway crest elevation. Infiltration losses were assumed to be zero. Reservoir routings of the estimated 24-hour PMF indicate that the project will handle approximately 50% of the PMF volume before overtopping if the low-level outlet is fully closed, or approximately 57% of the PMF volume before overtopping if the low-level outlet is fully open. Although both dams are constructed of erodible materials, and would probably fail when overtopped by flood waters, for purposes of this investigation, it was assumed that only the South Dam would fail and that all the discharge from a breach of the South Dam would enter the Pear Lake drainage area. These discharges were included in the inflow hydrographs to Pear Lake and subsequently to Boot Lake.

On the basis of the field inspection and the study of hydrologic and operational data, the Anchor Lake Dams conform to Corps guidelines with respect to discharge and/or storage capacity to handle the recommended SDF.

Evidence of significant foundation or embankment seepage was found at the downstream toe of the maximum embankment section of the North Dam and to the right of the conduit outlet of the South Dam. A bulge was found in the downstream rock wall at the maximum section of the North Dam. No piezometers are installed to measure water levels in the embankment, and there is no known internal drainage or filter system. Conditions described in this report suggest that both dams are marginally stable under normal pool conditions and do not conform to the recommended guidelines (Ref. 1) with respect to the stability of the downstream slope.

PRINCIPAL RECOMMENDATIONS

Due to the availability of storage between the normal pool elevation and the dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

Develop a downstream warning plan, for use in the event of possible dam overtopping or structural failure. Inspect the entire length of the outlet conduit and repair as required. Develop a formal maintenance plan. Remove all trees, brush, and root systems from the dam embankments.

A discussion of all of the many alternatives which exist for failure or overtopping of the dams and reservoirs in this watershed and the responses to these failures or overtoppings by downstream dams and reservoirs is very complex and beyond the scope of this preliminary study. It is recommended that additional, more-detailed studies be initiated on this watershed so that a better understanding of the complex situation is achieved.

Analyses should be performed by a qualified geotechnical engineer, experienced in dam design and construction, to determine if embankment modifications are required to provide adequate stability. Modify the project as the studies indicate.

Prior to performing engineering studies and remedial construction, coordinate all work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal Identification Number	MT-821 (South), MT-1483 (North)
Owner	Beaverhead Water Company
Operator	Beaverhead Water Company
Purpose	Irrigation
Location	Section 5 & 6, T5S, R11W Beaverhead County, Montana
Watershed	Tributaries to Birch Creek
Downstream Hazard Potential	Significant (both dams)
USGS Quadrangle	Torrey Mountain, Montana Polaris, Montana

2. RESERVOIR

Surface Area at Normal Pool	49 acres
Normal Storage (Spillway Crest)	400 acre-feet
Total Storage (Minimum Dam Crest)	510 acre-feet
Surcharge Storage	110 acre-feet
Drainage Area	0.46 square miles
Normal Pool Elevation	9152.5 feet (NGVD)
Reservoir Water Surface Elev. (9/20/79)	9145.0 feet (NGVD)

3. SPILLWAYS

	Principal (North)	Emergency (South)
Type	Uncontrolled earth and rock channel	Uncontrolled earth and rock channel
Crest Elevation	9152.5 feet (NGVD)	9154.4 feet (NGVD)
Crest Width	8 feet	4 feet
Spillway Capacity	194 cfs	4 cfs

4. OUTLET WORKS (SOUTH DAM)

Type	Controlled rectangular concrete conduit
Controls	Slide gate with manual rising stem
Size	24-inch x 18-inch rectangular
Length	48 feet
Inlet Invert	9144.4 feet (NGVD)
Outlet Invert	9144.0 feet (NGVD)
Normal Tailwater	Unknown
Discharge Capacity (Minimum Dam Crest)	50 cfs

5. DAM

	MT-821 Anchor South Dam	MT-1483 Anchor North Dam
Type	Earth and Rock	Earth and Rock
Maximum Height	11 feet	12 feet
Crest Length	130 feet	320 feet
Minimum Crest Elevation	9155.0 feet (NGVD)	9154.7 feet (NGVD)
Crest Width	12 feet	8 feet
Upstream Slope	1(V) on 2.2(H)	1(V) on 1.7(H)
Downstream Slope	1(V) on 1.9(H) for upper 6 ft; nearly vertical rock wall below	1(V) on 1.3(H) for upper 6 ft; nearly vertical rock wall below

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Anchor Lake Dams, owned and operated by the Beaverhead Water Company of Dillon, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Office of the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1) in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists, highly experienced in dam safety, from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines outline a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam;
(2) based upon an evaluation of the available data and a visual inspection;
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted; and
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, materials testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate

project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and neither action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and an interview with the owners. Records of infrequent inspection, dating back several years, were furnished for reference. No design drawings or foundation exploration results were available for review or analysis. Inspection procedures and criteria were those established by the "Recommended Guidelines for Safety Inspection of Dams" (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Seattle District Corps of Engineers;
Art Taylor, Civil Engineer, State of Montana, Department of Natural Resources and Conservation; and
Garth Taylor, President, Beaverhead Water Company.

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader;
Mike McMeekin, Hydrologist/Hydraulics Engineer; and
Gene Holtorf, Hydrologist/Hydraulics Engineer.

This report has been reviewed by representatives of the Beaverhead Water Company, the U.S. Forest Service, the Bureau of Land Management, and the Montana Department of Natural Resources and Conservation. Their written comments have been included in the Appendix of this report.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Anchor Lake is one of four high mountain lakes owned and operated by the Beaverhead Water Company, which are used to store snowmelt and runoff for irrigation. It is operated under a Department of Interior easement which was filed under the Public Lands Act of March 3, 1891. Anchor Lake (drainage area = 0.46 square miles) and Tub Lake (drainage area = 0.25 square miles) drain into Pear Lake (local drainage area = 0.76 square miles), which drains into Boot Lake (local drainage area=1.53 square miles). The total area of the watershed is approximately 3.0 square miles. Anchor Lake is located in Sections 5 and 6, T5S, R11W, and Section 31, T4S, R11W, Beaverhead County, Montana, approximately 22 miles northwest of Dillon, Montana, on Birch Creek.

Anchor Lake's natural storage capacity of approximately 20 acre-feet was increased to about 510 acre-feet with the construction of Anchor North Dam (MT-1483) and Anchor South Dam (MT-821) in 1904. There are two spillways for Anchor Lake. The principal spillway is located approximately 200 feet south of the right (south) abutment of the North Dam, and 450 feet northeast of the South Dam. The emergency spillway is located approximately 150 feet west of the South Dam. The low-level outlet is a 24-inch x 18-inch rectangular concrete conduit located in the South Dam and controlled by a rising stem slide gate (Photo 3). The operating controls are on top of a concrete inlet structure.

The North and South Dams are 12 and 11 feet high, respectively, and at the minimum dam crest elevation of 9154.7 feet, impound approximately 510 acre-feet of water. Based on a visual reconnaissance and engineering judgment, approximately 2 inhabitable structures, located about 10 miles downstream from Boot Lake along Birch Creek, could be affected by a sudden breach of either dam. Discharge through a breach of the North Dam would flow directly to Birch Creek. Discharge through a breach of the South Dam would reach Birch Creek by way of Pear Lake and Boot Lake, neither of which would be able to prevent the Anchor Lake discharge from reaching Birch Creek. The Anchor Lake Project, therefore, is classified as being small in size and as having a significant downstream hazard potential.

1.2.2 Regional Geology

The Pioneer Mountains lie in the southwest corner of Montana. They are bounded by the Anaconda Range to the north, the Beaverhead Mountains in the Bitterroot Range to the west across the Big Hole valley, and the Ruby and Tobacco Root Ranges to the east across the Beaverhead Valley.

The Pioneer Mountains are essentially composed of a complex suite of igneous rocks, the Boulder Batholith, which has intruded into the much older sedimentary and metamorphic rocks of the area. The intrusion of the Boulder Batholith, along with intensive block and thrust faulting, has been the major factor in the geologic structure of the Pioneer Mountains. Present topography is the result of Pleistocene glaciation and valley fill in the lower intermountain areas.

The northern Rocky Mountain region, prior to Late Cretaceous time, was essentially a flat plain partially flooded by shallow seas. At the end of the Mesozoic Era, of which the Creataceous is the last geologic epoch, this entire area became geologically active. Three things exemplify this activity: (1) Cretaceous uplift; (2) Late Cretaceous thrust faulting; and (3) Late Cretaceous-Tertiary intrusive activity, i.e., the Boulder Batholith. The regional uplifting of the continental crust brought the earth up in several north-south trending blocks. The west sides of the faulted blocks, or mountains, are higher in elevation and have characteristically abrupt scarps, while the east sides of the blocks have long, gentle slopes.

The uplifted land immediately became subjected to erosion. As the sediments were transported downslope, they filled the intermountain valleys with debris ranging from muds and sands to gravels and cobbles. These valley-fill sediments attain a depth of several thousand feet in the axis of the mountain valleys.

Pleistocene alpine glaciation of Wisconsin Age (12,000 years before present) sculptured typical alpine glacial features including cirques, headwalls and troughs in the upper elevations of the Pioneer Mountains. In lower elevations glacial deposits of terrace gravel, stream bed alluvium, landslide rubble, and glacial drift occur.

1.2.3 Seismicity

Anchor Lake North Dam (MT-821) and Anchor Lake South Dam (MT-1483), located in the Pioneer Mountains, lie in Seismic Zone 3 as indicated by the Seismic Zone Map (Ref. 1). The seismic probability of this regional setting is one of potential for major damage and is based on the known distribution of damaging earthquakes in the region.

The Preliminary Map of Young Faults in the United States, by the U.S. Geological Survey (Ref. 2), indicates suspected activity along the northern expanse of the Pioneer Mountains and Holocene activity directly east, along the northwestern side of the Tobacco Root Range. The Geologic Map of Montana shows extensive faulting prior to the Cenozoic Era in the southern portions of the Pioneer Mountains.

Local earthquakes significant enough to be reported in References 3 and 4 occur in 2 epicentral areas. One of these is to the northeast along a line from 20 miles northwest of Helena to 25 miles north of Bozeman, while the other is to the southeast in northeast Idaho, northwest Wyoming, and the adjoining areas of Montana. Of these two epicentral areas the former is 75 to 100 miles northeast and the latter is 50 to 150 miles southeast of the project site. Two earthquakes of significant intensity that occurred in the tri-state region southeast of the project site were the Hebgen Lake, Montana, earthquake (8 August 1959), that had an intensity of X (Modified Mercalli), and another southeast of Dillon, Montana, and southeast of the project area (23 November 1947), that had an intensity of VIII. The three largest reported earthquakes northeast of the Pioneer Mountains have had intensities of VIII. One of these earthquakes had its epicenter at a point 25 miles north of Bozeman (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935).

In the vicinity of the project there have been numerous other earthquakes in this century (Ref. 3 and 4). In an area bounded by the 44th and 46th parallels and by the 110th and 112th meridians (including the tri-state region), there have been more than 50 earthquakes with intensities of V and more than 10 with an intensity of VI. The closet reported earthquakes to the project site have occurred approximately 50 miles east near Ennis and Virginia City, Montana. The largest of these had an intensity of VI and occurred near Ennis (10 March 1977). The exact distance from the epicenter of this earthquake to the project site is not known.

The Pioneer Mountains lie in a highly seismically active area with the potential for a damaging earthquake. This warrants special attention be given to the dams in the area that have been constructed without consideration of the effects of earthquakes.

1.2.4 Site Geology

Anchor Lake lies in a strongly scoured cirque basin with talus footslopes, rock glaciers and rock land. The soils are patchy, very shallow silt loams and sandy loams.

The headlands are patterned grounds on gentle to moderate convex slopes with moderate to thick regolith (rock mantle). The soils are very shallow, well-drained silt loams and highly organic alpine turf and subalpine grassland. Very steep cirque headwalls, strongly scoured glacial troughwalls, and rock glaciers with very thin regolith occur below the headlands. There is no soil devleopment here, only rock land on basically an igneous and metamorphic bedrock surface. The natural lake is retained by a local terminal moraine. Surficial foundation soil is silty, gravelly sand.

1.2.5 Design and Construction History

According to Forest Service records, the Anchor Lake Dams were completed in 1904. Construction was supervised by George Metlin, Chief Engineer for Justin E. Morse, Contractor. As plans are not available, nothing is known about the placement of material in the dam. The existing low-level outlet pipe appears to have been placed during the construction of the dam.

Based on observations, the embankments of both dams appear to consist of a silty, gravelly sand core section with rockfill upstream sections and downstream slopes consisting of nearly vertical rock walls.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillways

The principal spillway for Anchor Lake is located between the North Dam and the South Dam. The spillway is an excavated, or blasted, earth and rock channel, as seen in Photos 14 through 16. The emergency spillway for Anchor Lake is located southwest of the South Dam and is also an excavated earth and rock channel (see Photos 17 through 19). Approximate dimensions and elevations were determined in the field for use in the calculation of the discharge capacity of each spillway.

The control section for the principal spillway is located near the spillway inlet at elevation 9152.5 feet. The approximate slope of the channel downstream from the control section is 3%. The channel has an average width of 8 feet at the bottom, with side slopes of approximately 1(V) on 2(H). The control section (crest elevation 9154.4 feet) for the emergency spillway is located 60 feet downstream from the lake's edge at the normal pool elevation of 9152.5 feet. The channel has a slope of approximately 3% downstream from the control section, a bottom width of 4 feet, and side slopes of approximately 1(V) on 2.5(H). The profile and a typical cross section for the principal and emergency spillways are shown on Plates 6 and 7. Both channels appear to be in good condition with no erosion damage. Both channels show signs of usage, but this could be a result of snowmelt runoff intercepted by the spillways in the spring of each year.

The discharge ratings for the spillways were computed by assuming critical depth at the control sections and computing water surface profiles upstream into the reservoir using Manning's "n" values of 0.04 and 0.035 for the principal and emergency spillways, respectively. The discharge capacity of the principal spillway varies from 0 cfs at the normal pool elevation, 9152.5 feet, to 194 cfs at the minimum crest elevation of the North Dam, 9154.7 feet. The discharge capacity of the emergency spillway ranges between 0 and 4 cfs at the elevations previously stated. Complete discharge rating curves for the principal and emergency spillways are shown on Plates 8 and 9, respectively.

2.1.2 Outlet Works

The low-level gravity outlet for Anchor Lake is located at Station 0+66 in the South Dam. The low-level outlet consists of a 48-foot-long, 24-inch x 18-inch rectangular concrete conduit (Photo 3, inlet; Photo 7, outlet) with a vertical slide gate for control. The controls are located on a tower at the top of the concrete inlet structure, slightly above the dam crest (Photos 3 and 4). At the time of the inspection, the gate was locked in the open position, but the inlet was almost completely blocked by debris. The concrete for the control structure is in very poor condition,

with spalling and large cracks in evidence. It is held together with cables and braced in several places with wood to keep it upright. The concrete appears to have no reinforcement.

The inlet and outlet elevations for the low-level outlet conduit are 9144.4 feet and 9144.0 feet, respectively. The capacity of the conduit, based on full pipe flow conditions, was computed to be about 45 cfs at the normal pool elevation and 50 cfs at the minimum crest elevation of the North Dam. The conduit flow currently possible is probably less than this amount, due to the amount of debris obstructing the inlet. All visible portions of the outlet conduit were inspected and found to be in reasonably good repair with the exception of a large crack visible in the top of the conduit at the outlet end. The complete outlet discharge rating curve for an unobstructed condition is shown on Plate 10.

2.1.3 Freeboard

The effective fetch for wind-generated waves for the North Dam is about 1000 feet, and the wave run-up and set-up on the embankment is estimated to be 2.5 feet (Ref. 5). An approximate 2-foot difference exists between the minimum crest elevation of 9154.7 feet and the normal pool elevation of 9152.5 feet. This vertical distance is considered inadequate in preventing wave overtopping (Ref. 6). Routings indicate that no freeboard exists during the recommended spillway design flood. At the time of inspection, the lake was at elevation 9145.0 feet, resulting in a 10-foot vertical distance between the lake level and minimum dam crest.

The South Dam has an effective fetch of about 725 feet and a resulting wave run-up and set-up of 1.9 feet (Ref. 5). An approximate 2.5-foot difference exists between the minimum crest elevation of 9155.0 feet and the normal pool elevation of 9152.5 feet, a difference considered adequate in preventing wave overtopping (Ref. 6). Routings indicate that no freeboard exists during the recommended spillway design flood.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 Climatology and Physiography

The climate of the area around Anchor Lake is continental and characterized by a large diurnal and seasonal temperature range. Extreme variability of wintertime temperatures results from the frequent occurrence of chinook winds, which follow a Pacific maritime air mass invasion. Summers are characterized by warm days with low humidity and cool nights. Winters are cold and highly variable in severity from year to year and within a given year.

Dillon, in Beaverhead County at an elevation of 5218 feet, is the climatological station nearest the project site. The precipitation and climatological data available from this station are not applicable to the project because of a 3948-foot elevation difference between Anchor Lake and the weather station. The average annual precipitation at Anchor Lake, as estimated from Soil Conservation Service graphs, is over 40 inches (Ref. 7).

At the project site, the expected date of the first freeze is August 13th, and the expected date of the last freeze is July 9th (Ref. 8).

Anchor Lake Dams are located on tributaries of Birch Creek, in the Pioneer Mountains and the Beaverhead National Forest. The drainage basin above and including Anchor Lake has an area of about 0.46 square miles, about 49 acres of which is water surface area. Basin elevations range from the normal pool elevation of 9152.5 feet to 10,294 feet at the top of Sawtooth Mountain. The average ground slope is about 27%. Basin vegetation consists of moderately thick pine and grasses on the lower basin area to sparse pine and rocky surfaces on the upper basin area (see Photo 1).

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 49 acres and a storage of about 400 acre-feet at the spillway crest elevation of 9152.5 feet. Storage of approximately 110 acre-feet is available between the spillway crest and the minimum crest elevation of the dam, 9154.7 feet. The total discharge for the principal and emergency spillways at the minimum dam crest is approximately 200 cfs. The discharge capacity of the facility would increase an additional 50 cfs if the low-level outlet were completely open and free of obstructions.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. A storm, the intensity of which approached probable maximum precipitation (PMP) intensity, did occur in parts of Montana in June 1964.

Inspection criteria (Ref. 1) recommend that a small-sized project with a significant downstream hazard potential be capable of handling a spillway design flood (SDF) in the range of the 100-year flood to one-half of the PMF. Because of the involved risk for this project, we recommend that the SDF be one-half of the PMF.

A PMP storm of 24-hour duration was applied to the basin. The 24-hour, 12-hour, 6-hour, and 1-hour PMP depths were estimated from National Weather Service Technical Paper 38 (Ref. 9) to be 15.1 inches, 12.8 inches, 10.4 inches and 6.4 inches, respectively. All 6-hour increments from 0 to 24 hours were arranged in accordance with criteria in Weather Bureau Hydrometeorological Report No. 43 (Ref. 10).

The PMF was assumed to result from a PMP storm in the late spring, over frozen ground. Thus, a constant soil loss rate of zero was applied throughout the 24-hour PMP storm in accordance with Corps of Engineers recommendations. Thus, the overall configuration of the 24-hour storm is not affected by the soil, and the basin rainfall is equal to the basin runoff for all storm increments. Direct precipitation onto the surface of the lake was also added with no losses.

2.2.4 Flood Routing

For routing the PMF through Anchor Lake, the lake level at the beginning of the PMP storm was assumed to be at the principal spillway crest elevation of 9152.5 feet, which would correspond to the normal pool condition. The total volume of the 24-hour PMF for Anchor Lake is approximately 370 acre-feet with a peak flow rate of approximately 4440 cfs. Two routings were made. The first routing indicated that with the control gate of the irrigation outlet closed, the project will handle, through storage and spillway discharge, approximately 50% of the PMF volume before the dams are overtopped. The second routing showed that with the control gate completely open, the project would handle approximately 57% of the PMF volume before the dams would overtop.

Since both dams are constructed of materials that will probably erode, both dams could fail when overtopped. However, for purposes of this investigation, it was assumed that only the South Dam would fail. Breach discharges from Anchor Lake were included in the inflow hydrograph for Pear Lake.

The PMF inflow hydrographs were developed using the SCS dimensionless unit hydrograph. These hydrographs were generated and combined using the HEC-1 (Dam Safety Version) computer program (Ref. 11). The reservoir routing of the PMF was made using the Modified Puls method contained in the HEC-1 program.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Embankments

South Dam

The 11-foot-high earth and rockfill South Dam is 130 feet long and has a crest width of 12 feet. The upstream slope is 1(V) on 2.2(H). The downstream slope is 1(V) on 1.9(H) for the upper 6 feet and is a nearly vertical hand-laid rock wall below that point. Borrow for the embankment appears to have been obtained locally; however, a borrow area was not readily visible. The material exposed on the crest of the South Dam is a silty sand matrix, containing nearly 50% gravel and cobbles, and is highly erodible. The upstream section of the embankment is composed of dumped rock, generally ranging in size from 6 inches to 24 inches in diameter.

The rock comprising the rockfill upstream section and the rock wall downstream section appears to be of igneous origin. No evidence was found of a granular bedding or filter course between the rock and the silty sand embankment materials. There were no noticeable sags or bulges on any of the surfaces of the embankment.

The only vegetated area of the embankment is the crest. The vegetation consists of approximately 25% coverage of trees and native weeds and grasses. The trees are mostly pine ranging from 2 to over 8 feet tall. The trees are concentrated primarily along the upstream and downstream shoulders (see Photos 4 and 5).

North Dam

The 12-foot-high earth and rockfill North Dam is 320 feet long and has a crest width of 8 feet. The upstream slope is 1(V) on 1.7(H). The downstream slope is 1(V) on 1.3(H) for the upper 6 feet and is a nearly vertical hand-laid rock wall below that point. Borrow for the embankment appears to have been obtained locally; however, a borrow area was not readily visible. The material exposed on the crest of the dam is a silty sand matrix, containing nearly 50% gravel, cobbles, and boulders. This material is highly erodible. The upstream section of the embankment is composed of rock, which appears to be hand-placed and which generally ranges in size from 6 inches to 18 inches in diameter.

The rock comprising the rockfill upstream section and the rock wall downstream section appears to be of igneous origin. No evidence was found of a granular bedding or filter course between the rock and the silty sand embankment materials. A bulge was found in the rock wall forming the downstream face of the North Dam, centered approximately 80 feet from the left abutment. Soil, normally present between the rocks forming the wall, was not visible in the bulged area, and voids could be seen beneath the rocks. It could not be determined whether the bulge and voids were caused by slope instability or seepage or were the result of a portion of failed wall being rebuilt. This bulge can be seen in the left-center of Photo 13.

2.3.2 Foundation Conditions, Seepage, and Drainage

South Dam

The South Dam is probably founded on silty, gravelly sand similar to that used in the embankment. This material is considered to be quite pervious. Evidence of seepage was found at the downstream toe, although no free water was found. To the right of the conduit outlet there is a type of leafy plant which seems to grow only where there is an abundant supply of water (see Photos 5 and 6). In addition, in the same area, there is a small ditch which would carry water into the outlet channel when seepage occurs. No water was found flowing from the suspected seepage areas. Pool elevation on the date of the inspection was 9145.0 feet.

There was no evidence to indicate that the dam included any type of internal drain, nor are there any piezometers installed in the dam.

North Dam

The North Dam is probably founded on silty, gravelly sand similar to that used in the embankment. This material is considered to be quite pervious. The only evidence of seepage is near the downstream toe at the maximum section, approximately 50 to 80 feet right of the left abutment. In this area, leafy weeds are growing which are similar to those found right of the conduit outlet at the South Dam. In addition, there is a channel nearly two feet wide leading away from this area. The channel contains no vegetation and could carry a considerable quantity of water. No free seepage water was found during the inspection.

There was no evidence to indicate that the dam included any type of internal drain, nor are there any piezometers installed in the dam.

2.3.3 Stability

North Dam

There is no stability analysis available for review. The evidence of seepage and the very steep downstream slope suggest marginal embankment stability during high pool conditions. This is further suggested by the observed bulge in the rock wall. It is our judgment that the stability of the North Dam does not conform to the recommended guidelines (Ref. 1).

South Dam

There is no stability analysis available for review. The evidence of seepage and the very steep downstream slope suggest marginal stability during high pool conditions. Because the South Dam is similar in height, design, and materials to the North Dam, which has an observed bulge in its downstream rock wall, it is our judgment that the stability of the South Dam does not conform to the recommended guidelines (Ref. 1).

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 General

Operation and maintenance of Anchor Lake and Dams is the responsibility of the Beaverhead Water Company with technical assistance provided by the Forest Service. Although a plan for operation and maintenance of the facility was not available at the writing of this report, Forest Service inspection reports dating back many years infer such responsibility. In addition, the reports indicate the dam has had a history of maintenance problems.

Access to the project is very difficult. This limits regular maintenance to those functions which can be performed by hand.

2.4.2 Dams

There is no formal plan for performing periodic maintenance on the Anchor Lake Dams. Inspection reports by the Forest Service and correspondence indicate a general lack of adequate maintenance for many years. Maintenance is needed on the South Dam, particularly on the low-level inlet and the crest (tree removal). The current maintenance needs of the North Dam consist mainly of tree removal.

2.4.3 Reservoir

As with the dams, the reservoir has no formal plan for operation and maintenance and has received very little attention for many years. A fairly large amount of debris, mostly dead trees, covers the shore of the reservoir. The debris is also partially blocking the low-level inlet.

2.4.4 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the Anchor Lake Dams, supplemented by analysis of the project in terms of the recommended guidelines' performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, both Anchor Lake South Dam and Anchor Lake North Dam are classified as small in size and, based on our visual inspection and judgment, both have a significant downstream hazard potential. The recommended spillway design flood (SDF) for this project is 50 percent of the PMF. Based on reconnaissance level investigations, the project is capable of handling 50% of the PMF without overtopping. Therefore, the Anchor Lake Project conforms with the inspection guidelines' criteria for spillway and/or storage capacity.

3.1.2 Embankment Dams

South Dam

Leafy vegetation and a diversion ditch along and below the downstream toe right of the conduit outlet were taken as evidence of seepage at that location. No other seepage was found; however, on the date of inspection, the pool was not against the face of the dam.

A visual inspection of the embankment revealed no longitudinal or horizontal cracks. Embankment slopes are very steep with evidence of possible seepage at higher pool elevations; therefore, the embankment is probably marginally stable at best.

North Dam

Seepage evidence found in the downstream toe in the vicinity of the maximum section included leafy vegetation and a water-cut channel leading away from the embankment. No free water was expected to be found, since there was no water against the upstream face of the embankment. A bulge in the downstream rock wall was found in the vicinity of the maximum section. In the area of the bulge, soil and vegetation had been removed from between the rocks, leaving visible voids. The bulge may be the result of seepage through the embankment at that point, may be evidence of slope instability, or may be the result of improper reconstruction of a previously failed section of wall.

There is no internal drainage system nor any piezometers installed in either the North or South Dams. The phreatic surface locations cannot be determined at this time.

Based on experience with similar structures and materials and on the evidence obtained during the inspection, it is our opinion that Anchor Lake North Dam and Anchor Lake South Dam do not conform to Corps guidelines (Ref. 1) with respect to stability during normal pool conditions. Insufficient information is available, however, to evaluate stability.

3.1.3 Spillways

Both the principal and emergency spillways were found to be in good condition with no erosion damage evident. Both spillway channels appear to be highly resistant to erosion. Therefore, high flows which would accompany a storm of PMP magnitude probably would not cause severe damage to the channels. Also, since both channels are located considerable distances from either embankment, high flows in the spillways would not affect the integrity of the embankments.

There are no log booms present to protect either spillway from floating debris.

3.1.4 Outlet Works

The concrete low-level inlet structure and gate tower is in poor repair. The structure is presently held upright by boards propped up against the sides and between the wing walls. The inlet is filled with debris, and there is no trash rack. The top of the structure, where the operating controls are located, is held together with cables and is in extremely poor condition (see Photos 3 and 4). The whole facility appears as if it could completely collapse at any time.

All visible portions of the outlet conduit were inspected and found to be in reasonably good repair with the exception of a large crack visible in the top of the conduit at the outlet end.

3.1.5 Spillway and Reservoir Capacity

The lake storage and spillway discharge capacities are insufficient to prevent overtopping of the dam during the PMF. This investigation has estimated that during the 24-hour PMP storm the project can safely pass 50% of the PMF, which is the recommended spillway design flood.

3.1.6 Operation and Maintenance

Operation and maintenance are performed by the Beaverhead Water Company, with technical assistance provided by the Forest Service. There is no formal operation plan for the reservoir. Water from spring runoff is stored in the reservoir and is released from the outlet as needed for irrigation. Consequently, the lake level fluctuates seasonally. The remoteness of the site requires special consideration in any formal operation plan.

There is no formal maintenance plan for the dam, and the facility has a history of inadequate maintenance. The poor condition of the low-level

inlet, the debris in the low-level inlet, and trees on the crests of both embankments are indications of the lack of sufficient recent maintenance.

There is no formal warning system or plan of action to warn downstream inhabitants in the event of impending dam failure.

3.2 RECOMMENDATIONS

Due to the availability of storage between the normal pool elevation and the dam crest, the present project provides a degree of flood protection to the downstream area. The intent of the recommendations in this report is to maintain or improve project safety without decreasing this existing flood protection.

1. Immediately develop, implement, and periodically test a downstream notification plan for use in the event of dam distress.

2. Inspect the conduit and repair as required.

3. Repair or replace the concrete inlet structure and gate tower. Include a workable trash rack.

4. Remove all trees and bushes and root systems from all embankment surfaces and adequately backfill and compact the resulting holes.

5. Provide log booms to keep debris out of both spillways.

6. Conduct more-detailed hydrologic and hydraulic routing studies, involving all four of the Beaverhead Water Company's Birch Creek watershed dams, to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate.

7. Have a qualified geotechnical engineer, experienced in dam design and construction, determine if embankment modifications are required to provide adequate stability. Modify the project as studies indicate.

8. Develop and implement a periodic maintenance plan for the dams and appurtenant structures. Because of the remoteness of the project site, the maintenance plan should include frequent condition inspections whenever water is impounded above the natural lake level.

9. Establish a program for periodic, comprehensive, safety inspections at no more than 5-year intervals. These inspections should be performed by engineers qualified in the design, construction, operation, and maintenance of earth dams.

Prior to performing engineering studies and remedial construction, coordinate the work with the U.S. Forest Service and the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U. S. Army Corps of Engineers, Office of the Chief of Engineers, Report to the U. S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspections of Dams", Washington D. C., Department of the Army, May 1975.

2. Howard, K. A., et al, "Preliminary Map of Young Faults in the United States as a Guide to Possible Fault Activity," U. S. Geological Survey, Reston, Virginia, 1978.

3. U. S. Geological Survey, "Earthquake Information Bulletin," Washington D. C., 1973-1978.

4. U. S. Department of Commerce, Earthquake History of the United States, Publication 41-1, Washington D. C.

5. U. S. Army Corps of Engineers, Office of the Chief of Engineers, "Wave Run-up and Wind Set-up on Reservoir Embankments," Engineer Technical Letter No. 1110-2-221.

6. U. S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, Water Resources Technical Publication, U. S. Government Printing Office, Washington D. C., 1974.

7. U. S. Department of Agriculture, Soil Conservation Service, "Average Annual Precipitation in Montana," Portland, OR, 1977.

8. Caprio, J. M., "Montana: Average Dates of Freeze," Folders No. 81, 82, and 83, Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana, March 1965.

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10. U. S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Probable Maximum Precipitation, Northwest States, Hydrometeorological Report No. 43, Washington, D. C., November 1966.

11. U. S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Users' Manual for Dam Safety Investigations, Davis, California, September 1978.

(PHOTO 1) Anchor Lake, Aerial View

(PHOTO 2) South Dam, Upstream Face, Aerial View

(PHOTO 3) South Dam, Conduit Inlet and Control Structure

(PHOTO 4) South Dam, Control Works from Dam Crest

(PHOTO 5) South Dam, Downstream Face from Left Abutment

(PHOTO 6) South Dam, Downstream Face at Maximum Section Seep Area in Foreground

(PHOTO 7) South Dam, Conduit Outlet

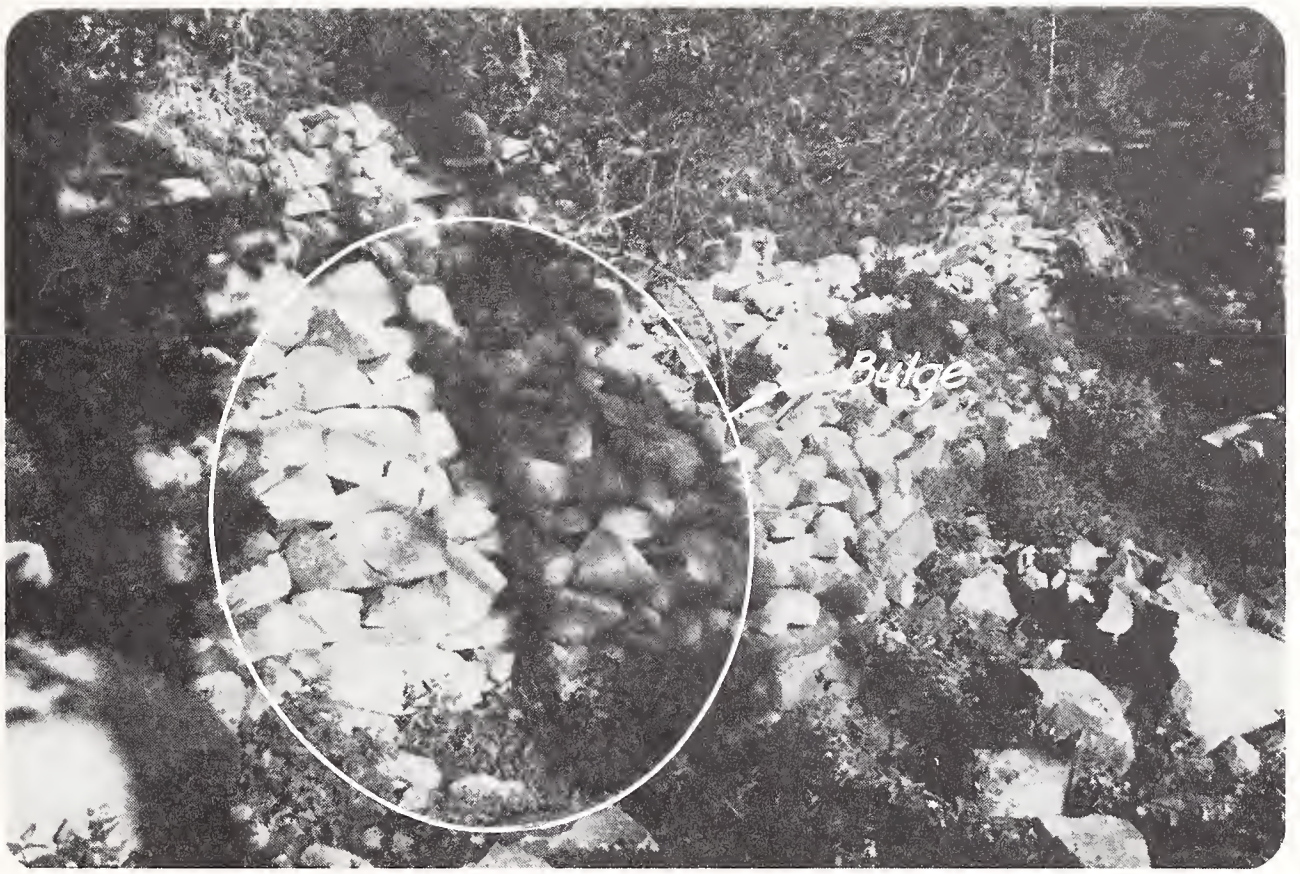
(PHOTO 8) South Dam, Downstream View from Crest

(PHOTO 9) North Dam, Upstream Face from Right Abutment

(PHOTO 10) North Dam, Upstream Face from Left Abutment

(PHOTO 11) North Dam, Hand-Placed Riprap on Upstream Face

(PHOTO 12) North Dam, Downstream Face from Right Abutment

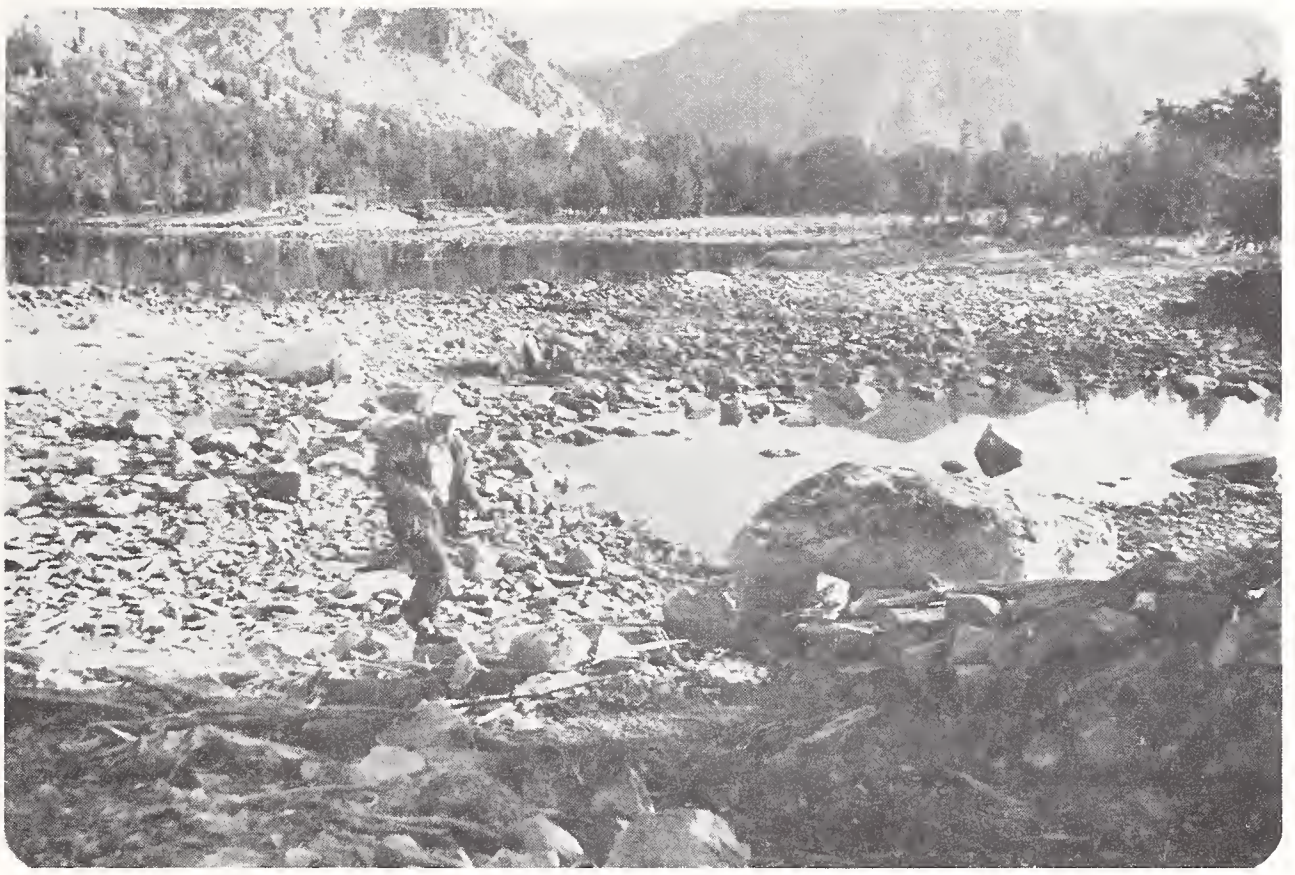


(PHOTO 13) North Dam, Downstream Face at Maximum Section, near Left Abutment. Seepage Area in Foreground.

(PHOTO 14) Principal Spillway, Approach Channel Looking Upstream

(PHOTO 15) Principal Spillway, Approach Channel Looking Downstream

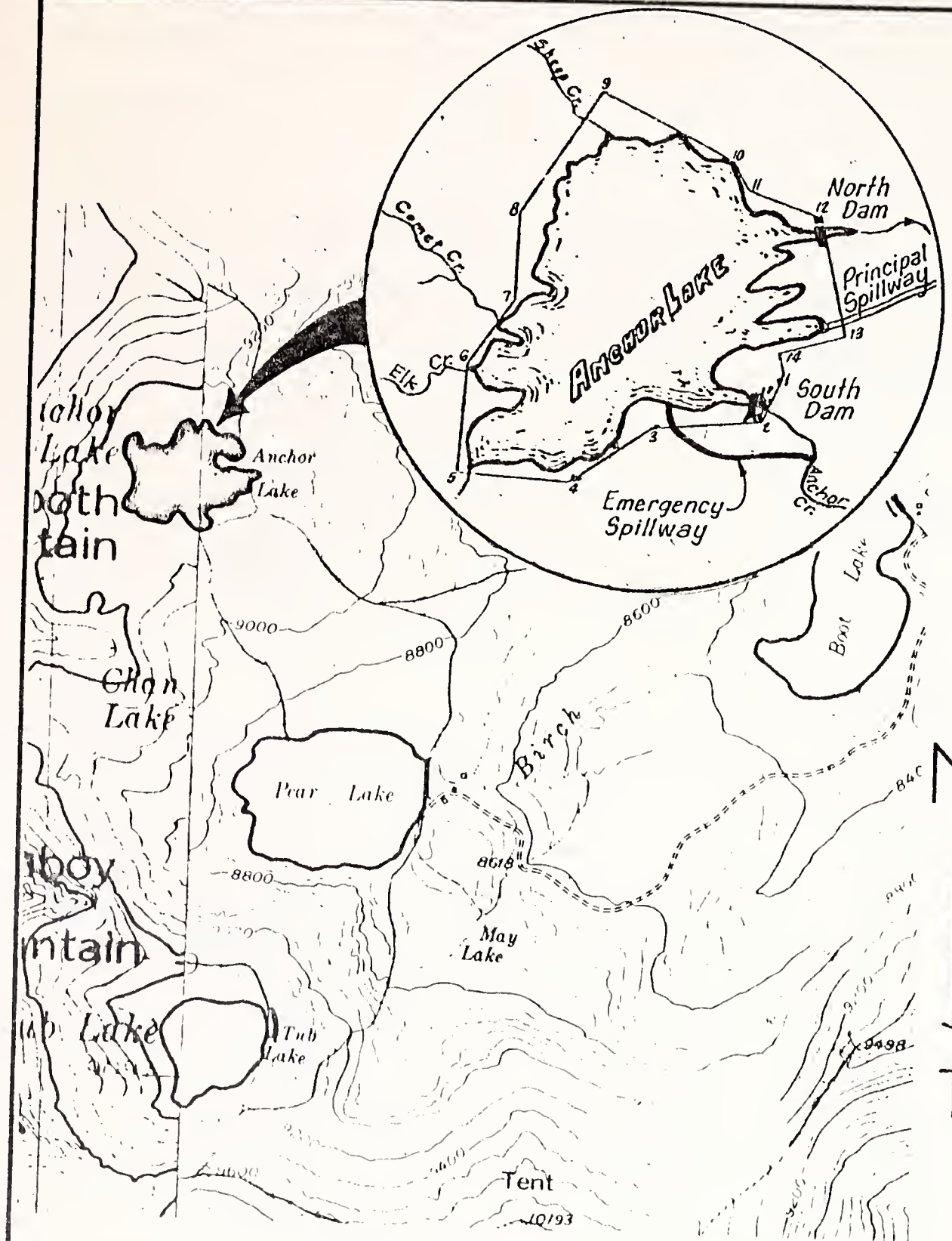
(PHOTO 16) Principal Spillway, Control Section Looking Downstream



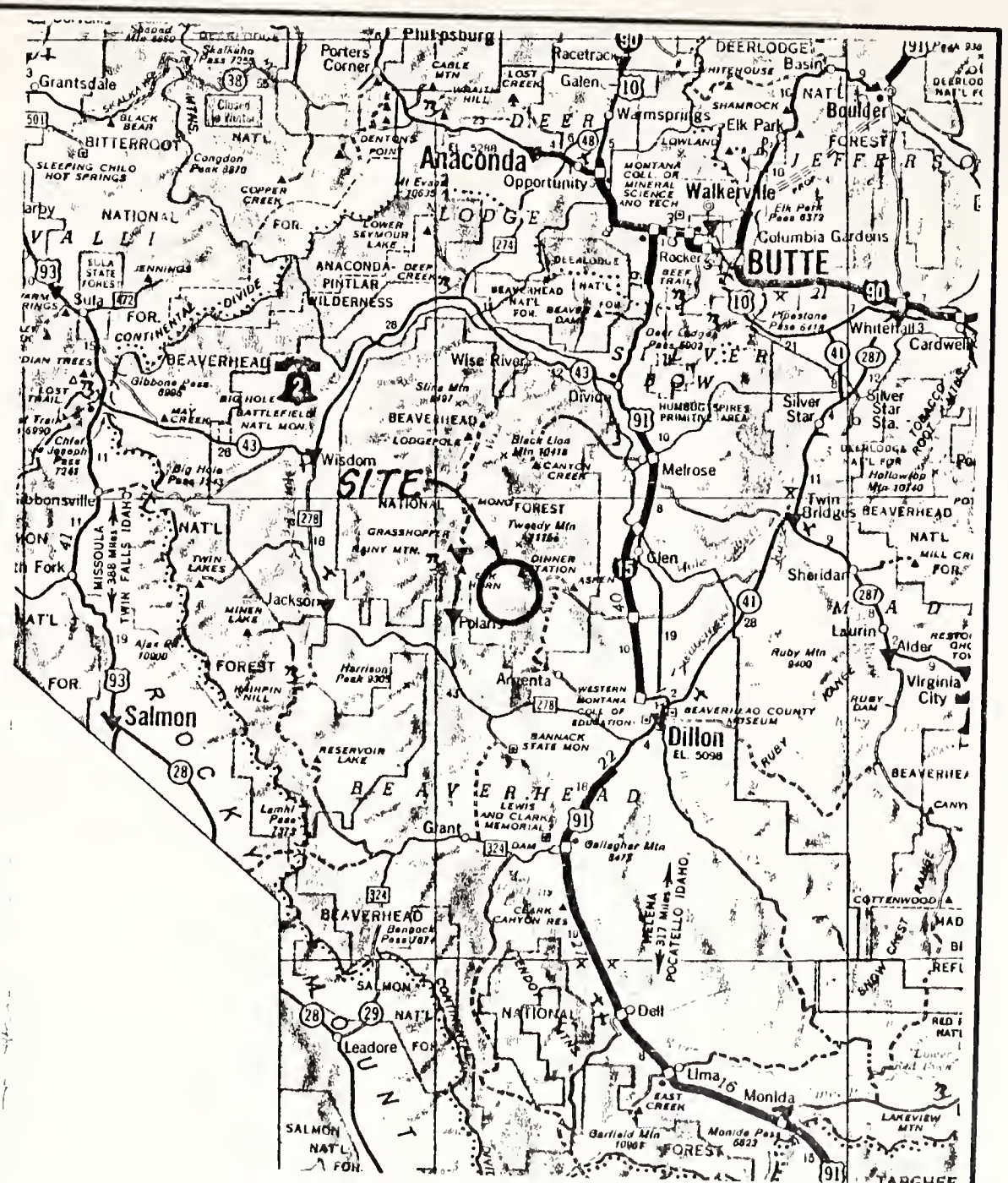
(PHOTO 17) Emergency Spillway, Approach Channel Looking Upstream

(PHOTO 18) Emergency Spillway, Exit Channel and Control Section Looking Upstream

(PHOTO 19) Emergency Spillway, Exit Channel
Looking Downstream



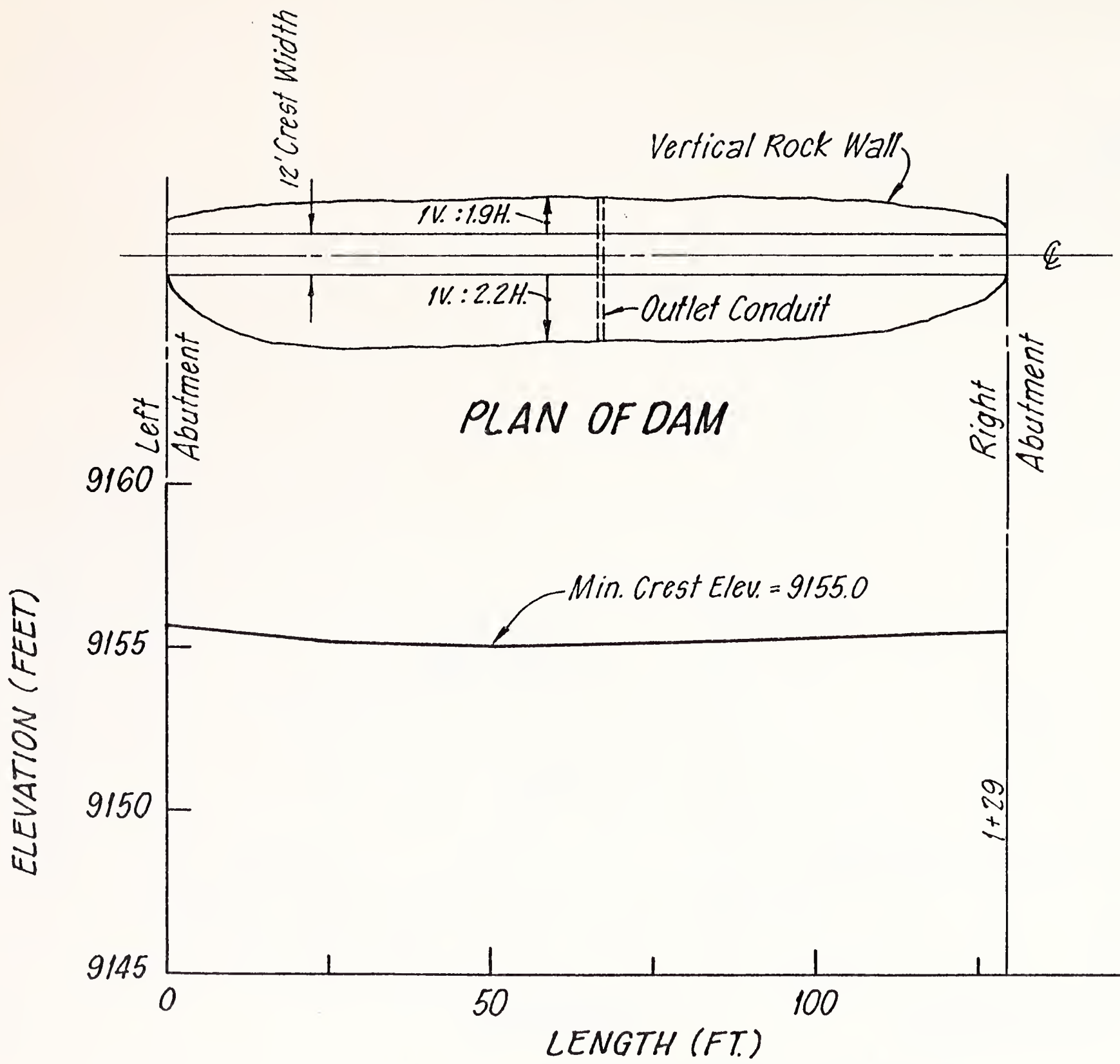
SITE PLAN



VICINITY MAP

PLATE 1
ANCHOR LAKE DAM
SITE PLAN & VICINITY MAP

ANCHOR SOUTH DAM
MT-821



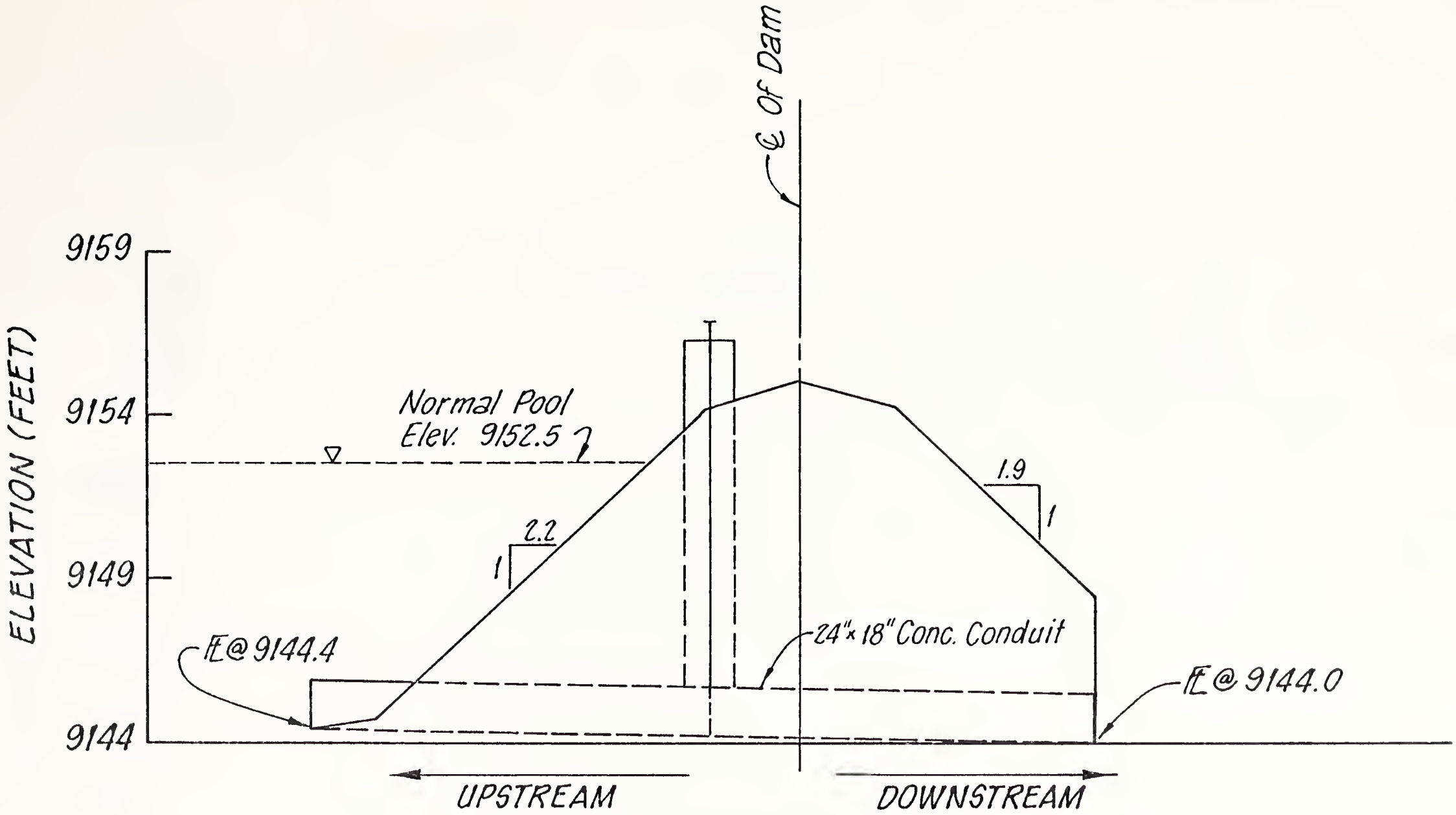
PLAN OF DAM

DAM CENTERLINE PROFILE

Scale: 1" = 25' Horiz.
1" = 5' Vert.

PLATE 2

ANCHOR SOUTH DAM
MT-821



DAM CROSS-SECTION

Scale: 1" = 10' Horiz.
1" = 5' Vert.

PLATE 3

ANCHOR NORTH DAM
MT-1483

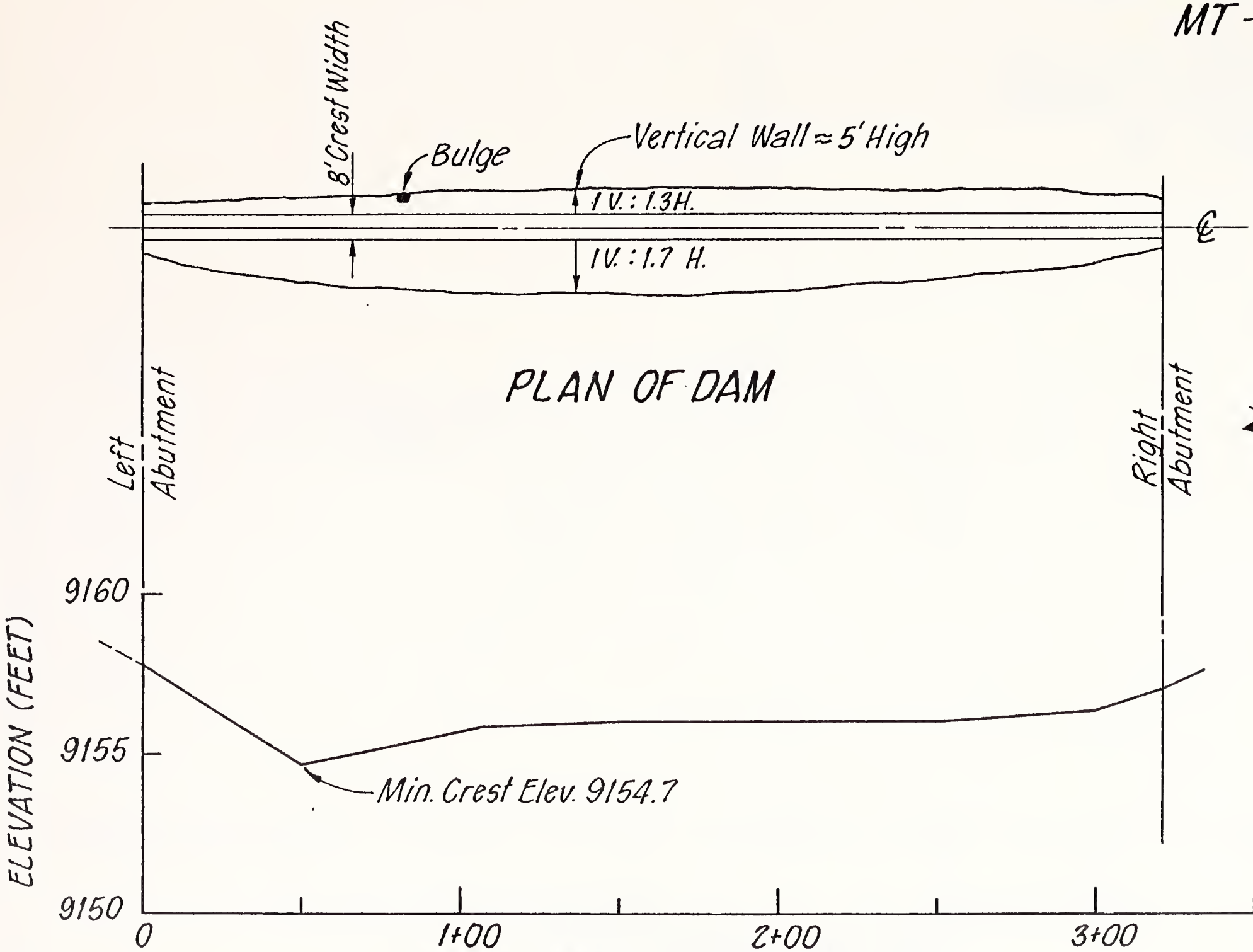
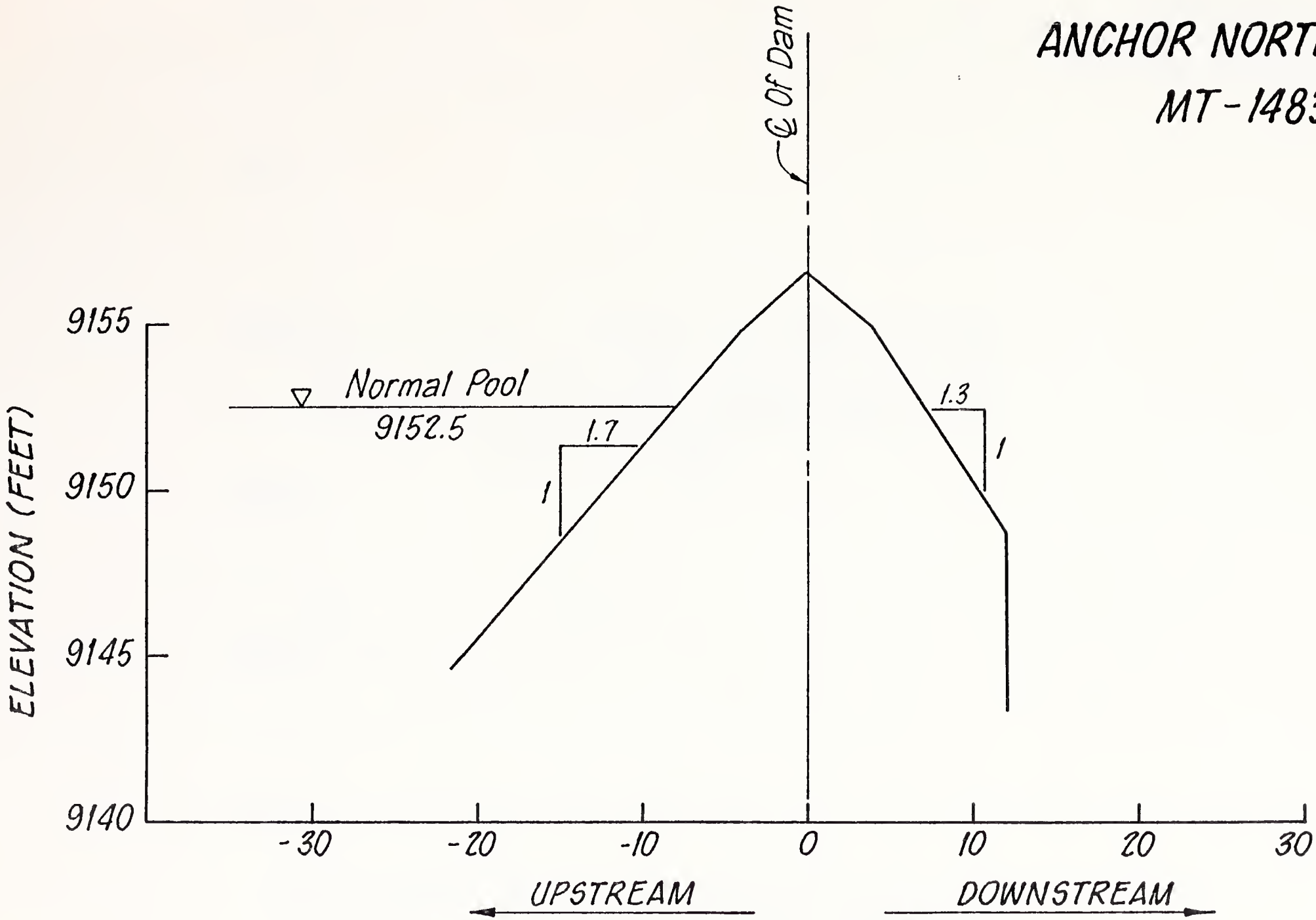


PLATE 4

ANCHOR NORTH DAM
MT-1483

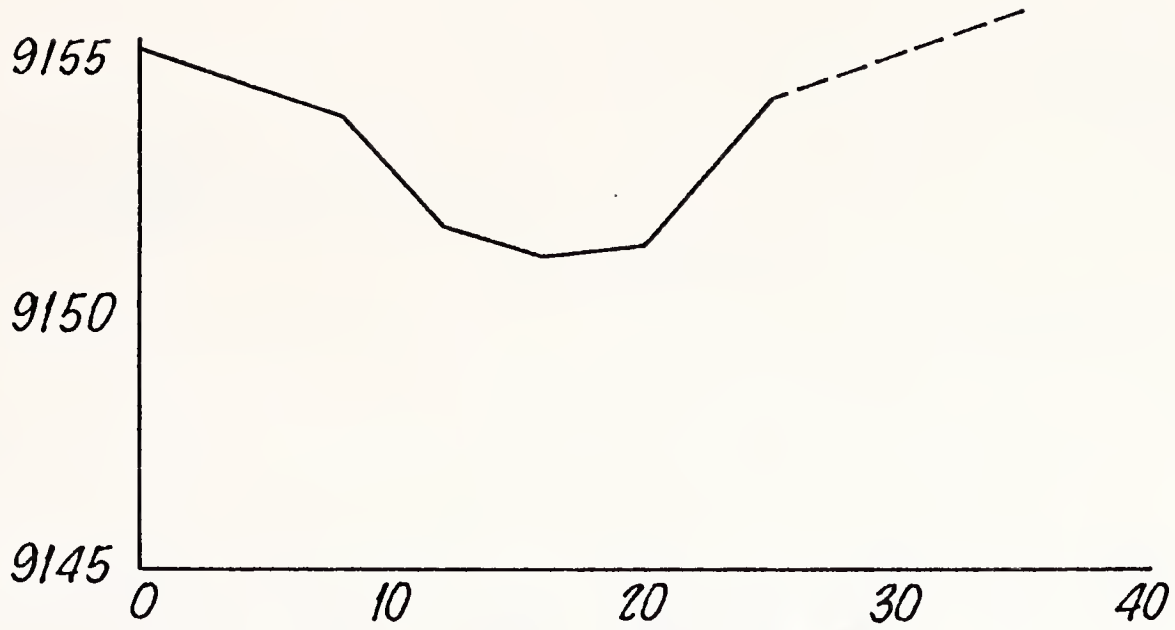


DAM CROSS-SECTION

Scale: 1" = 10' Horiz.
1" = 5' Vert.

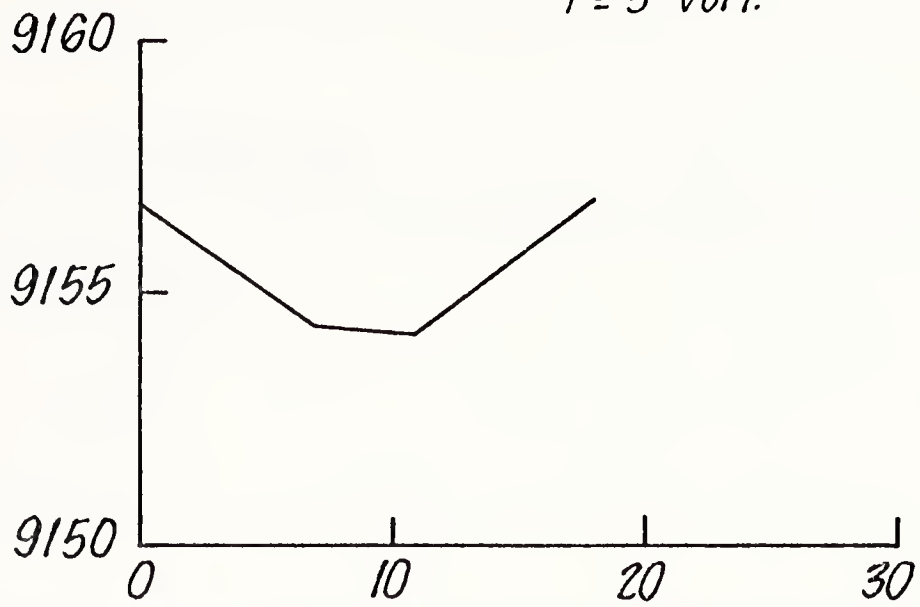
PLATE 5

ANCHOR LAKE
SPILLWAY CROSS-SECTIONS



PRINCIPAL SPILLWAY CROSS-SECTION

Scale: 1" = 10' Horiz.
1" = 5' Vert.

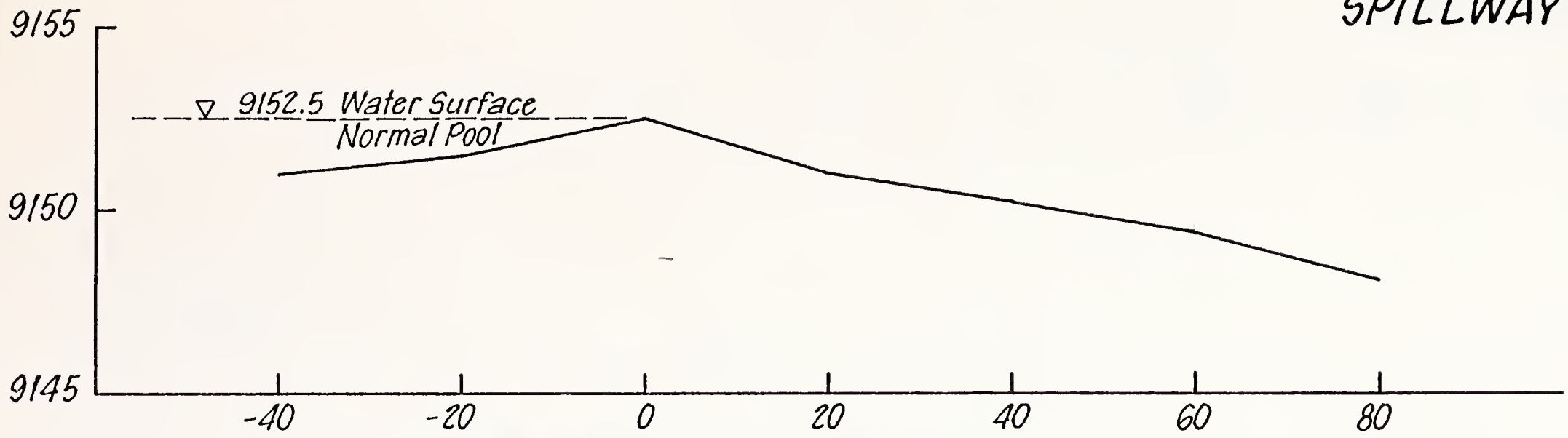


EMERGENCY SPILLWAY CROSS-SECTION

Scale: 1" = 10' Horiz.
1" = 5' Vert.

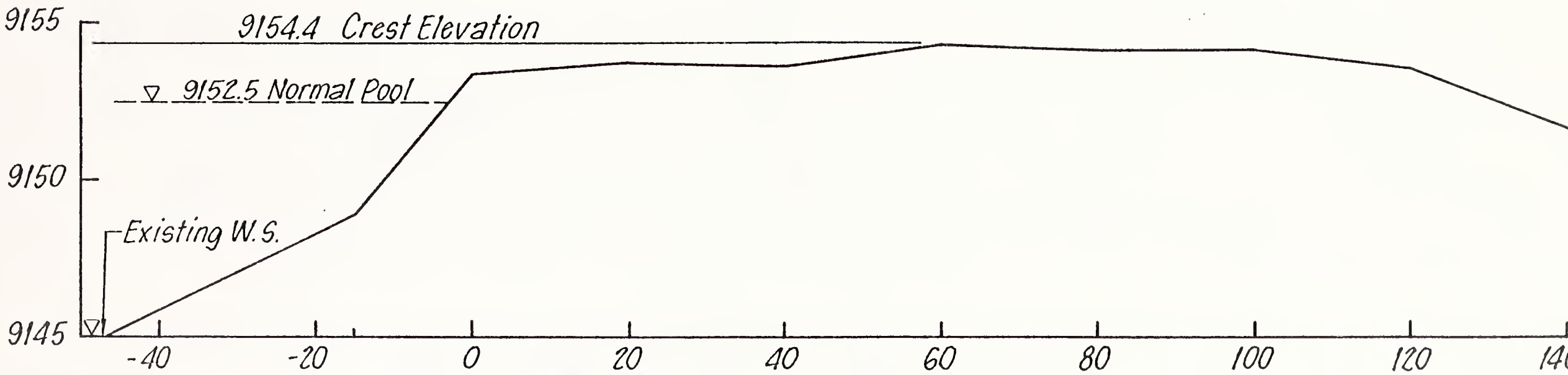
PLATE 6

ANCHOR LAKE
SPILLWAY PROFILES



PRINCIPAL SPILLWAY PROFILE

Scale: 1"= 20' Horiz.
1"= 5' Vert.



EMERGENCY SPILLWAY PROFILE

Scale: 1"= 20' Horiz.
1"= 5' Vert.

PLATE 7

ANCHOR LAKE
ELEVATION- AREA
AND STORAGE CURVES

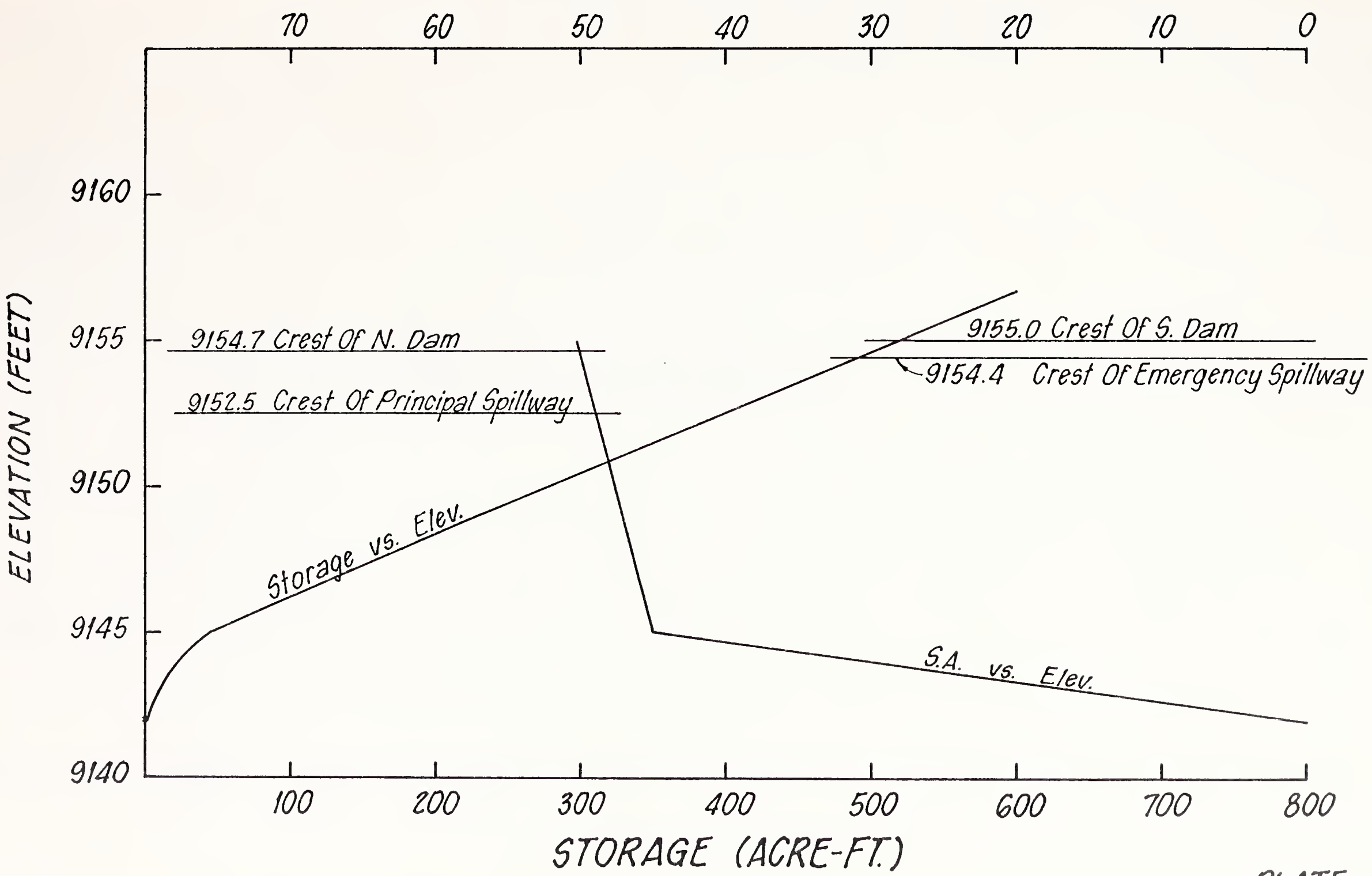


PLATE 8

PRINCIPAL SPILLWAY DISCHARGE RATING CURVE

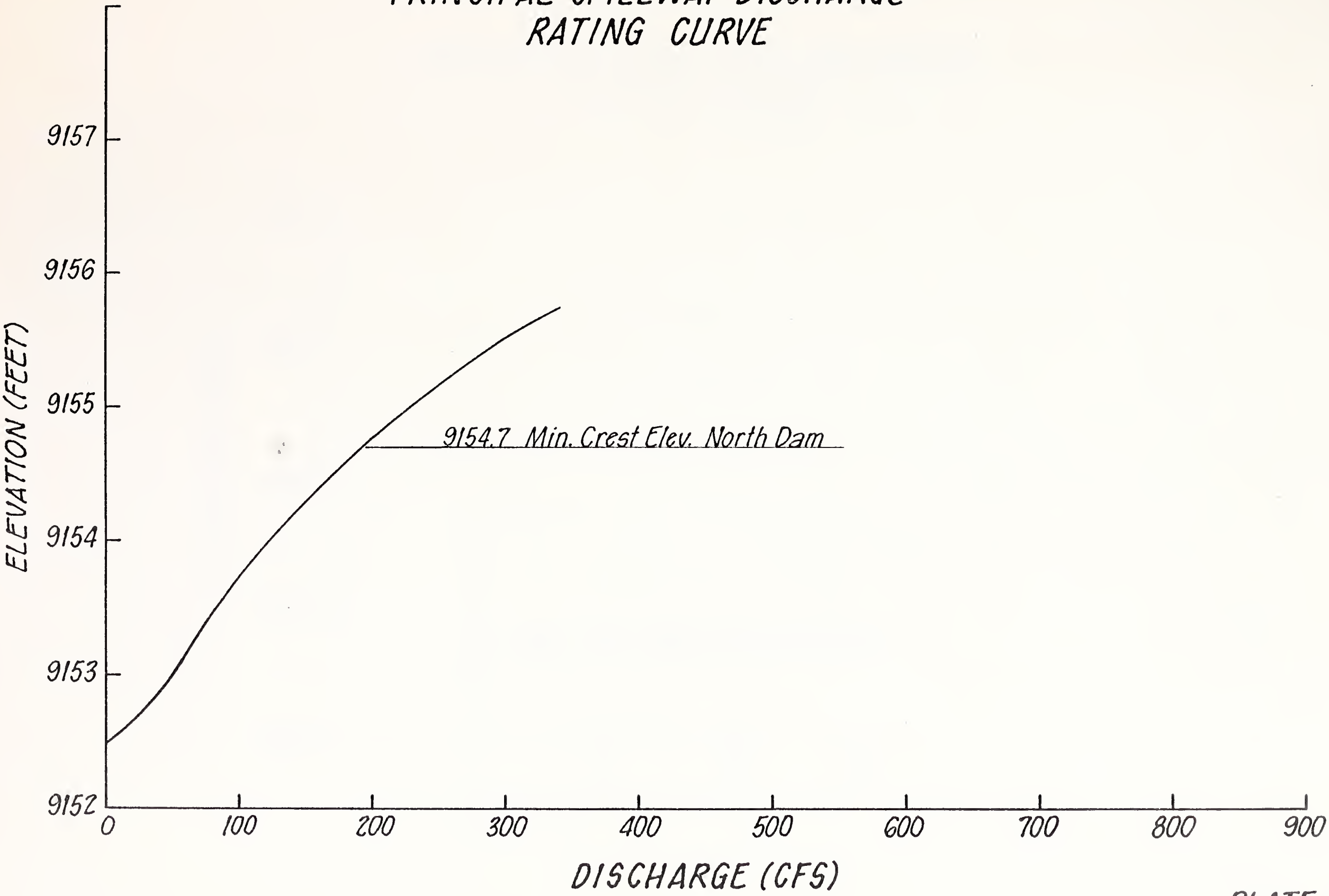


PLATE 9

EMERGENCY SPILLWAY DISCHARGE RATING CURVE

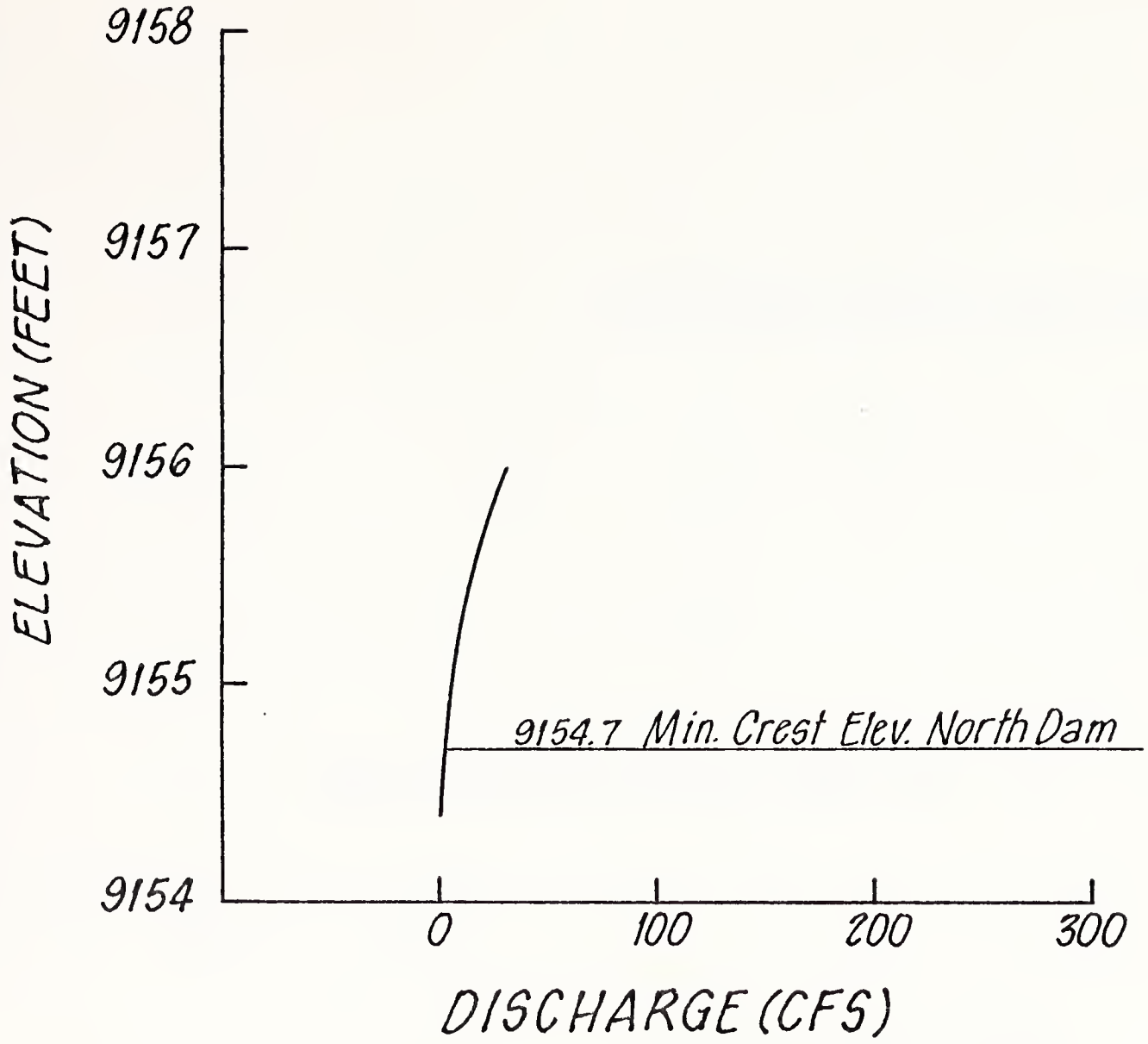


PLATE 10

24" x 18" RECTANGULAR CONCRETE CONDUIT
DISCHARGE RATING CURVE

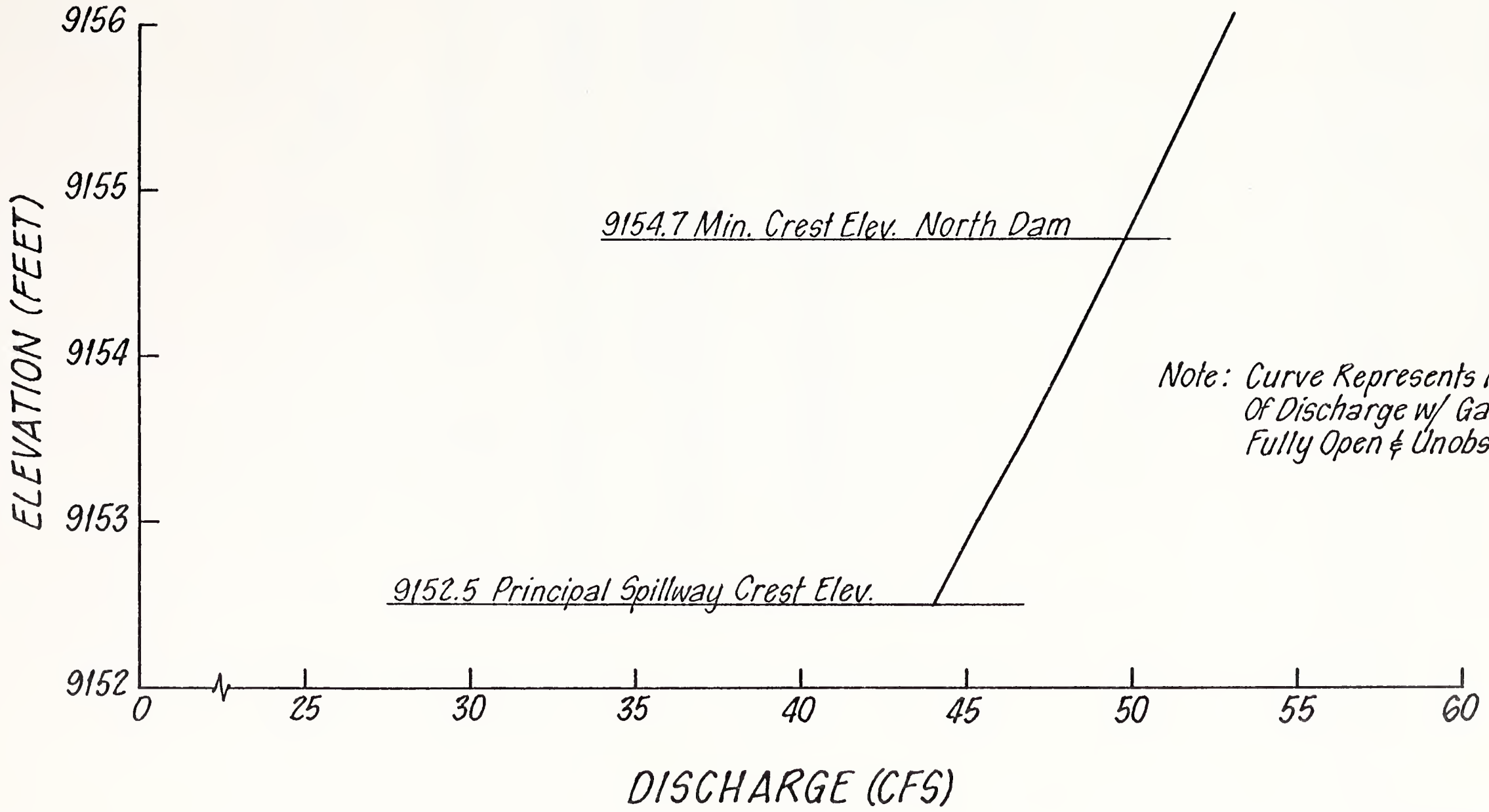


PLATE 11

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

December 11, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Attn: Ralhp Morrison

Re: Hoskins-Western-Sonderegger, Inc. Dam Safety Report on Anchor Lake Dams (MT-821-South, MT-1483-North)

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Anchor Lake Dams.

Sincerely,

Richard L Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RD/AT/lj

"AN EQUAL OPPORTUNITY EMPLOYER"

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

7530

DEC 2 2 1980

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

We have reviewed the Phase I draft report for the Anchor Lake Dams and have the following comments.

It is difficult to justify engineering expense for stability studies, either field or laboratory, for this or other dams in the Birch Creek drainage, until their hazard to human life is determined by a proper hydrologic study.

Thank you for the opportunity to review the report.

Sincerely,

Beryl Johnston

BERYL JOHNSTON
Acting Director
Engineering

IN REPLY REFER TO:

9100 (941)

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
222 North 32nd Street
P.O. Box 30157
Billings, Montana 59107

DEC 16 1980

Mr. Sidney Knutson, P.E.
Asst. Chief, Engineering Division
Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

Final drafts for Phase I Safety Inspection and Evaluation reports for Tub Lake and Dam Project, MT-822; Pear Lake and Dam Project, MT-820; Anchor Lake and Dam Project, MT-821 (South) and MT 1483 (North); and Boot Lake and Dam Project, MT-823 all located in Beaverhead County, Montana have been reviewed.

We have no additional information or comments to add to the draft reports. The opportunity to review the reports is appreciated.

Sincerely yours,

Henry T. Hammersmark

Henry T. Hammersmark
Chief, Branch of Engineering

BEAVERHEAD WATER COMPANY

Dillon, Montana

6825 Highway 91 North
Route 1
Dillon, Montana 59725

Mr. Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Subject: Anchor Lake Dams
MT-821, MT1483

Dear Mr. Knutson:

Enclosed for your consideration are our review comments on the Phase I Inspection Report on the subject dams. We hope they will be of value to you in preparation of the final report. They were made in consultation with Stensatter Druyvestein and Associates, Consulting Engineers, Missoula, Montana.

We wish to thank you for the opportunity to make comments and look forward to cooperating in efforts to improve water resource development.

Sincerely,

Garth Taylor, President
Beaverhead Water Company

Enclosure

December 1980

REVIEW COMMENTS
by
Beaverhead Water Company, Dillon, Montana
on
Phase I Inspection Report
Anchor Lake and Dams
Beaverhead County, Montana
MT- 821 (South)
MT-1483 (North)

The Beaverhead Water Company is grateful for this opportunity to comment on the Phase I Inspection Report on the Anchor Lake Dams. We are vitally interested in these and other project dams as productivity of lands owned by members of our Company are highly dependent on safe, reliable water storage. Although maintenance of the dams to supply irrigation water is paramount, it is also important to recognize the additional benefit of providing some flood control storage.

We recognize our obligations for providing safe water storage consistent with reasonable criteria for the size of structures and hazards involved. However, because the West Bench Irrigation District is heavily obligated to the Federal Government for loans on a new gravity sprinkler system, it has very limited available funds. Therefore, it is very important that any required work be really necessary and consistent with actual conditions.

The following comments are made in response to your letter of November 25, 1980 for consideration in preparation of the final report.

I Inspection and Safety Criteria

The value of guidelines for implementation of the National Dam Inspection Program is recognized as being very important. We generally agree with provisions in the "Recommended Guidelines for Safety Inspection of Dams" prepared by the Corps of Engineers. But we feel it is equally important to recognize and remember the basis for use of these guidelines. As noted in the Preface to these guidelines, "Safety must be evaluated in the light of peculiarities

and local conditions at a particular dam... The establishment of rigid criteria or standards is not intended." The Preface further states that the "guidelines are intended to be flexible" and contains the following paragraph:

> "Conditions found during the investigation which do not meet guideline recommendations should be assessed by the investigator as to their import from the standpoint of the involved degree of risk. Many deviations will not compromise project safety and the investigator is expected to identify them in this manner if that is the case. Others will involve various degrees of risk, the proper evaluation of which will afford a basis for priority of subsequent attention and possible remedial action."

Therefore, as will be pointed out in more specific comments, we think that evaluations and recommendations for each dam should be consistent with the particular circumstances.

II Inspection

The primary purpose of Phase I investigations is to identify those dams which may pose hazards to human life or property. This is good. However, we are not pleased with far reaching safety evaluations and costly recommendations based on brief site visits of a couple hours or less. We think that if potentially serious conditions exist, or if costly recommendations are made, then they should be made based on a more thorough investigation and analysis by experienced engineering personnel. In this case, they should have a background in high mountain dam construction and hydrology. This is consistent with the intended use of the guidelines.

III Existing Dams

It is important in any investigation and evaluation of a dam to keep in mind the difference between new design criteria and evaluation criteria for an existing structure. In some aspects they are similiar or even identical, but in others they are different. For example, slope stability of dams, about 75 years old in this case, can be based primarily on actual experience or observation rather than an estimate based on laboratory tests. Here again experience is important as many other dams in Western Montana are constructed of similar or identical soils. As another example, the need for and value of installing and monitoring piezometers is highly questionable.

IV Classification

The hazard potential classification of "significant" is based on "...approximately 2 inhabitable structures located about 10 miles downstream from Boot Lake ..." We question the accuracy of this rating and believe it should be "low". Was a flood routing done past these structures? Were cross sections and elevations taken near these structures to determine if loss of life would be expected if they were occupied? Are they in fact used or inhabited a significant amount of time?

This is highly important as the degree of risk affects spillway capacities, freeboards and other features on these and other dams.

V Hydrology

In general, we believe that the hydrologic analyses performed under this study are inadequate to serve as a basis for any significant changes in the dams, spillways or hazard ratings. We agree that not enough is known about high mountain basin hydrology to accurately predict exact storm or snowmelt runoff. But we don't agree that an ultra conservative approach should be

followed because of this lack of knowledge or data. To begin with, we think a Q_{100} evaluation flow is much more realistic for a low hazard structure such as this. The guidelines recommend Q_{50} to Q_{100}.

With regard to a Probable Maximum Flood (PMF) analysis, to go from Probable Maximum Precipitation (PMP) to PMF with no infiltration or other deductions certainly is conservative, but not necessarily realistic for this situation. Also, the basis for using a 24-hour PMP is unknown and unsupported.

It may be a matter of wording, but in the last paragraph on page 12 of the report it states that no freeboard exists during the "design" flood at PMF. Although the design flood determined in 1905 $\pm$ is unknown, it most assuredly wasn't PMF. This could be very confusing or cause unnecessary alarm for non-technical readers not familiar with the situation.

In summary, we think that for small projects such as this one, that appropriate "safe flood rating criteria" should be established at somewhat less than new design criteria. It doesn't seem reasonable to totally ignore the 75 years that this project has experienced.

IV Flood Warning System

Considering the size and remote, unattended location of these dams, and the determination that only "approximately 2" inhabitable structures would be directly affected by a dam failure, the recommendation to "Immediately develop, implement, and periodically test an emergency warning system..." seems totally inappropriate. If there was any advance notice, it would seem that the best plan would be to directly notify anyone living along the stream in person or through the sheriff's department.

VII Maintenance and Repair Recommendations

These are generally acceptable except for items previously covered. Another exception would be the removal of all root systems from bushes and trees. As the trees are small and "...concentrated primarily along the upstream and downstream shoulders.", we don't think this is necessary. In addition, we do not concur with the need for "...frequent condition inspections whenever water is impounded above the natural lake level."

The remoteness of the site make inspections, maintenance and repairs difficult and expensive, but we agree that improvements can be made in these areas.

Beaverhead Water Company

Garth Taylor, President

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

26 January 1981

Garth Taylor, President
Beaverhead Water Company
6825 Highway 91 North
Route 1
Dillon, Montana 59725

Dear Mr. Taylor:

Thank you for providing comments on the draft dam safety reports for your company's dams: Anchor Lake Dams, MT-821 and MT-1493; Tub Lake Dam, MT-822; Boot Lake Dam, MT-823; and Pear Lake Dam, MT-820. Your comments have been considered in preparation of the final reports and all your comments will be appended to the final reports.

I am gratified that you and your company have such a keen interest in dam safety and I share your view about properly maintaining the structures without having to do unnecessary engineering studies or remedial work.

The inspections were conducted by experienced engineers who used the inspection guidelines developed by the Corps of Engineers in consultation with states and other engineering organizations, both within and outside the Government. The guidelines are used as a screening tool to determine if existing dams are in need of further study and/or remedy. The Corps of Engineers has no enforcement authority in implementing report recommendations.

The inspecting engineers used judgement in arriving at the downstream hazard classification for your dams. Because the downstream hazard potential is so important to what a dam's capability must be in controlling floods, we have recommended that additional basin hydraulic and hydrology studies be undertaken by you to better define the interrelationships of your dams and the potential hazards of dam failure and to base each project's needed flood handling capability on that more in-depth study. This study should form the basis for all safety-related activities at each site. Both the United States Forest Service and the Montana Department of Natural Resources and Conservation's Engineering Bureau concur in this approach.

NPSEN-FM
Garth Taylor, President

Your concern about our recommendations on downstream warning plans is well taken. Our intent here is to have some workable plan to promptly notify the downstream residents and interests in case of dam distress. We are not advocating any alarm system such as sirens, etc. Your idea of having the affected parties notified by the Sheriff or someone designated for that purpose is the kind of plan we meant, but it should be a formal written and coordinated plan showing who has responsibility.

Sincerely yours,

Sidney Knutson